



Standard Guide for Selection and Use of Flat Strapping Materials¹

This standard is issued under the fixed designation D4675; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

This guide covers two common categories of flat strapping materials: steel and nonmetallic. Within each of these two broad categories there are distinct types that lend themselves in differing degrees to particular applications.

The goal of this guide is to help the user focus on the desired elements of performance or service, and the unique properties of each strapping material in order to judge which of these strapping products is best suited for the intended strapping application. For further information, consult with your strapping supplier, your carrier, and any packaging/loading regulations applicable to your products. It is of particular importance, for both safety and satisfactory performance, that the user informs the strapping supplier of all intended uses and usage conditions that may differ from industry custom and practice or from intended strapping applications. Likewise, the user needs to inform the strapping supplier of any practice of the user's carrier that the user believes may differ from any requirement or recommendation of the carrier's association or of any applicable ASTM or regulatory provisions. The user also should inform the strapping supplier of the following expected conditions: load, unit, or package characteristics (rigid, expanding, shrinking, or combination); severity of handling; nature of transport equipment; storage conditions (stacking height and weight); exposure to environmental conditions; extreme temperatures (particularly if prolonged outdoor exposure is anticipated); exposure to chemicals; exposure to abrasive surfaces; and exposure to sharp or pointed objects that can cause nicks, scratches, or holes in the strapping. There are other materials not covered by this guide, which may also offer acceptable solutions or may be used in conjunction with flat strapping to provide acceptable solutions for the user's intended application. Examples of accessories, such as, edge protectors, seal protectors, etc. are shown in Fig. 1.

Strapping may be recyclable but must never be reused. Contact your supplier for further information.

Table of Contents

Section

Introduction	
List of Figures	
List of Tables	
1. Scope	
2. Referenced Documents	
3. Terminology	
4. Significance and Use	
5. Safety Hazard Guidelines	
6. General Considerations	
7. General Uses	
8. Strap Tension	
9. Packaging Design	
10. Load, Unit, and Package Securement Configuration	
11. Strap Selection	
12. Joining Methods and Properties	
13. Coatings, Finishes, and Resistance to Deterioration of Physical Properties	
14. Environmental Considerations	
15. Lubrication	
16. Equipment for Strapping Application	
17. Strap Application	
18. Testing and Evaluation	

Table of Contents
Section

19. Evaluation of Strap Failure
 20. Keywords
 Supplementary Requirements
 Disclaimer and Contact Information

List of Figures

Title	Figure No.
Various Strapping Applications	1
Strap Cutting Techniques	2
Correct and Incorrect Applied Strapping	3
Notch Joint with Seals	4
Crimp Joint with Seals	5
Sealless Interlocking Joints	6
Loop Joint Secured to Stake Pocket	7
Loop Joint Placement	8
Buckle Styles	9
Crimp Joint Seals	10
Overlap Sealless Joints	11
Feedwheel Hand Tool Tensioning Application	12
Snap-On (Open) and Semi-Open Seals	13
Windlass Type Hand Tool Application	14
Thread-On (Closed) and Push Type (Overlap) Seals	15
Push Type Hand Tool Application	16
Nested Stack (Magazine Feed) Seal	17
Combination Tension and Seal-Feed Hand Tool Application	18
Intersection or Cross Tie Seal	19
Various Strapping Take-Up and Tensioning Methods	20
Corrugated Fiberboard Box Strap Placement	S1.1
Cleated-Panel Box Strap Placement	S1.2
Nailed Wood Boxes Strap Placement	S1.3
Wire Bound Box Strap Placement	S1.4

List of Tables

Title	Table No.
Strapping Applications Commonly Used for Packaging, Unitization, and Load Securement	1
Examples of Different Package Types	2
Appropriate Strapping Use as a Function of Environmental Conditions	3
Potential Causes for Strap Failure	4
Suggested Minimum Sizes of Steel and Nonmetallic Strapping for Corrugated Fiberboard Boxes	S1.1
Suggested Minimum Sizes of Flat Steel Strapping for Cleated-Panel Boxes	S1.2
Suggested Minimum Sizes of Flat Steel Strapping for Nailed Wood Boxes	S1.3
Weight of Contents Versus Length of Top Cleat	S1.4

1. Scope

1.1 This guide¹ covers information on flat strapping materials (steel and nonmetallic) for the prospective user wanting initial guidance in selecting a strapping material and information on suggested application methods for use in packaging (closing, reinforcing, baling, bundling, unitizing, or palletizing), and loading applications (load unitization and securement to transport vehicle). The use applies to handling, securement, storage, and distribution systems.

1.2 Carrier associations have established certain packaging and loading requirements that (in some cases) specify the type of strap, the minimum size or strength, the type of joint or seal,

and the number of straps, seals, and joints that must be used for particular types of shipments or under certain conditions. Users should consult with their carriers initially to determine if there are applicable published requirements. Individual carriers may establish their own requirements. (See 2.2.)

1.3 *Limitations*—This guide is not intended to give specific information as to how strapping must be used in any particular packaging or loading situation. Rather, it is intended to be informational in nature and is offered as a starting point for the testing of strapping being considered by the user. Thorough user testing is essential, as is a review of pertinent regulations that can influence strap selection (size and type), and application methods.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

¹ This guide is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.25 on Palletizing and Unitizing of Loads.

Current edition approved May 1, 2014. Published August 2014. Originally approved in 1987. Last previous edition approved in 2014 as D4675 – 14. DOI: 10.1520/D4675-14A.

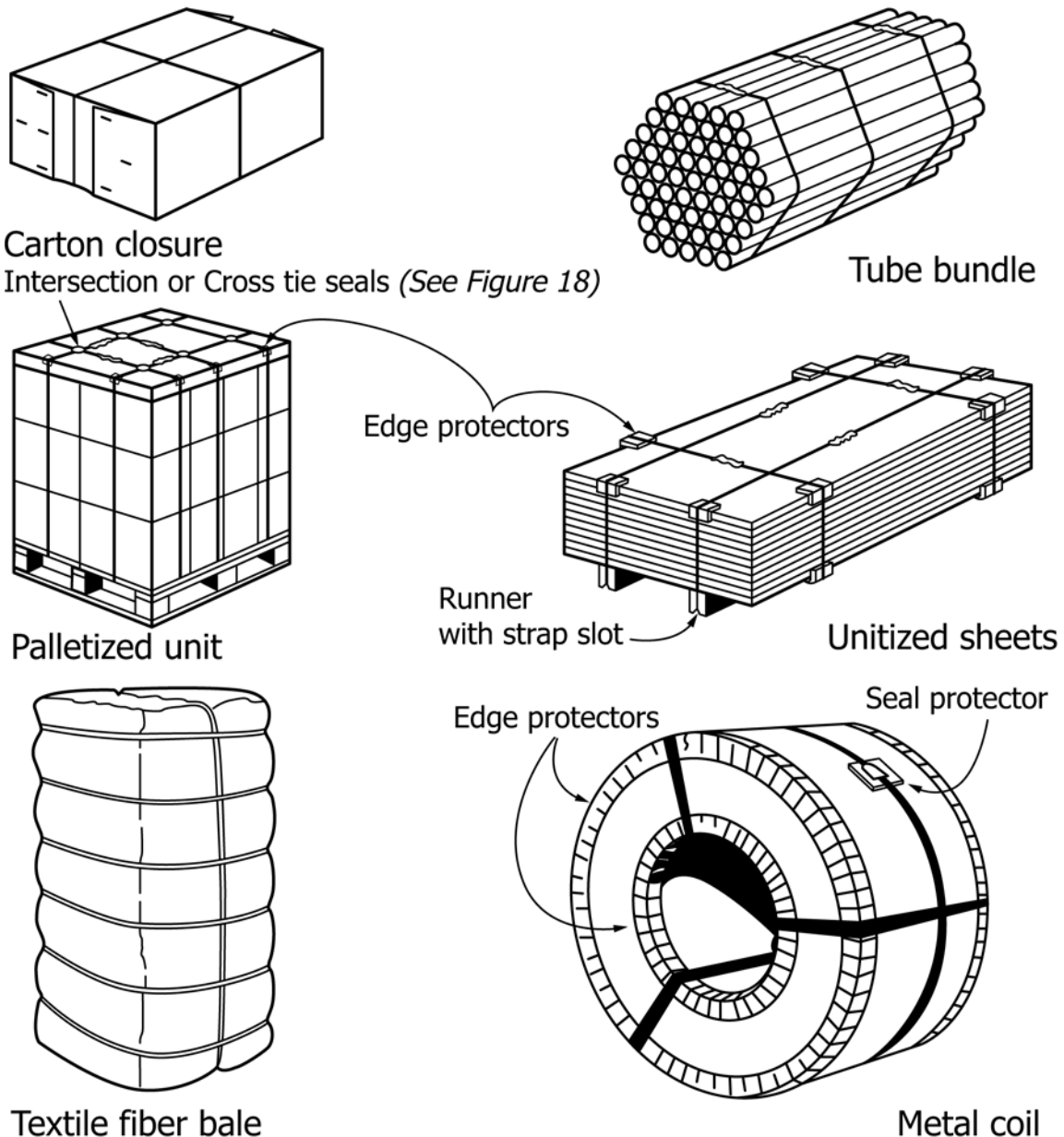


FIG. 1 Various Strapping Applications

1.5 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific safety hazard guidelines, however, are provided in Section 5.

2. Referenced Documents

2.1 ASTM Standards:²

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[D996 Terminology of Packaging and Distribution Environments](#)

[D3950 Specification for Strapping, Nonmetallic \(and Joining Methods\)](#)

[D3953 Specification for Strapping, Flat Steel and Seals](#)

[D4169 Practice for Performance Testing of Shipping Containers and Systems](#)

2.2 Other Standards (most current revisions):

[Uniform Freight Classification Code, Rule 41, Section 9](#)³

³ Available from National Railroad Freight Classification, available from Uniform Classification Committee, 222 South Riverside Plaza, Chicago, IL 60606.

National Motor Freight Classification 100-L, Item 222, Section 7⁴

ISTA, International Safe Transit Association, Pre-Shipment Test Procedure⁵

Association of American Railroads (AAR/TTCI)—Closed Car Loading Methods and Open Top Loading Rules⁶

IMO/ILO/UN ECE Guidelines for Packing or Cargo Transport Units (CTUs)⁷

Driver's Handbook on Cargo Securement⁸

3. Terminology

3.1 *Definitions*—For general definitions of packaging and distribution environments see Terminology D996.

3.2 *Definitions of Terms Specific to This Standard*: The following refers to the characteristics and properties of strapping materials. These can be objectively measured to some extent and are used to rank the relative effectiveness of different strapping materials in different applications. The definitions given here are for the purposes of this guide only and do not necessarily reflect general usage or ASTM standard definitions. Some properties are common to both steel and nonmetallic strapping. Other properties pertain to just steel strapping or to nonmetallic strapping only.

3.2.1 *break strength*, *n*—the longitudinal tensile force that is applied to cause a strap to rupture. (See Specifications D3950 and D3953.)

3.2.2 *chemical contamination*, *n*—exposure to chemicals which may degrade the strap's physical properties. (See Section 13.)

3.2.3 *corner break strength*, *n*—the reduced break strength due to the strapping being bent around a corner or edge. (See Specification D3953.)

3.2.4 *dead stretch (creep)*, *n*—strain (elongation) resulting from constant tensional stresses over time.

3.2.5 *ductility in bending (resistance to “work hardening”)*, *n*—refers to the ability of steel strapping to deform without rupture under the tensile stress resulting from bending, or its resistance to work hardening. It is the opposite of “brittleness.” Ductility is related to corner break strength and closely associated to strength and elongation. (See Specification D3953.)

3.2.6 *elongation at break*, *n*—the increase in strapping length (strain) when the tensional loading (stress) gets high enough to cause strap failure. (See Specifications D3950 and D3953.)

3.2.7 *energy-to-break*, *n*—the energy/force (total area under the stress-strain curve), resulting from strength and elongation properties required to break a strap.

3.2.8 *environmental resistant properties*, *n*—the ability of steel or nonmetallic strapping to withstand degradation from (but not limited to) exposure to sunlight, low and high humidity, and caustic chemicals.

3.2.9 *initial applied tension (IAT)*, *n*—highest amount of stress induced into the strap while the tensioning mechanism is still engaged.

3.2.10 *initial retained tension (IRT)*, *n*—the stress that remains in the strap immediately after completion of the joint and removal of the tensioning equipment.

3.2.11 *joint efficiencies*, *n*—joint strength divided by the minimum breaking strength of the strap, expressed as a percentage (For minimum acceptable percentage values, see Section 12, and Specifications D3950 and D3953.)

3.2.12 *joint strength*, *n*—the highest longitudinal tension (strain) that must be applied to cause a strap joint to fail. A failure at the gripper marks (outside of the joint) made by the hand tool, strapping head, or tensile tester specimen holding grippers is not to be considered the strength of the joint.

3.2.13 *lubrication*, *n*—an intentionally applied substance on the strap surface that lowers the coefficient of friction.

3.2.14 *mechanism*, *n*—device used in application of strapping, such as tensioner and sealer, combination tool, or power strapping equipment.

3.2.15 *moisture sensitivity*, *n*—the degree to which mechanical properties degrade due to the presence of moisture or moisture vapor. (See Section 13.)

3.2.16 *notch sensitivity*, *n*—the measure of a strapping material's ability to resist tearing or breaking due to a nick or cut.

3.2.17 *settling tolerance*, *n*—the ability of a strap to remain taut when used to confine a dimensionally shrinking load, unit, or package.

3.2.18 *shear plane*, *n*—the contact surface area between two items at which they move relative to one another when parallel and opposing forces are applied to these areas. The parallel application of forces causes the items to slide against one another.

3.2.19 *system strength*, *n*—the strength of an applied strap (closed loop) including both the strap and joining method.

3.2.20 *temperature sensitivity*, *n*—the degree to which the mechanical properties degrade due to extreme low or high temperatures.

3.2.21 *tension transmission*, *n*—the ability of strapping to slide around a corner/edge during tensioning.

3.2.22 *ultraviolet (U.V.) light resistance*, *n*—the degree to which the mechanical properties degrade due to ultraviolet ray exposure. U.V. inhibitors are available for all types of nonmetallic strapping.

⁴ Available from National Motor Freight Traffic Association (NMFTA), 1001 N. Fairfax St., Alexandria, VA 22314, <http://www.nmfta.org>.

⁵ Available from International Safe Transit Association (ISTA), 1400 Abbot Road, Suite 160, East Lansing, MI 48823–1900, <http://www.ista.org>.

⁶ Available from Association of American Railroads, Transportation Technology Center, Inc. (AAR/TTCI), 55500 Dot Road Pueblo, CO 81001, <http://www.aar.com>.

⁷ Available from International Maritime Organization, Publishing Service, 4 Albert Embankment, London, SE1 7SR, United Kingdom, <http://www.imo.org>.

⁸ Available from Driver's Handbook on Cargo Securement, 1200 New Jersey Avenue, SE, Suite W60-300, Washington, DC 20590, <http://www.fmcsa.dot.gov/documents/cargo/cargosecurement-16-04.pdf>.

3.2.23 *unit strap lifting method (USLM)*, *n*—a specialized application for overhead lifting and transport of large and heavy loads, units, or packages primarily at port facilities. (See [Table 1](#).)

3.2.24 *yield point*, *n*—the stress at which a material begins to deform physically. Prior to reaching the yield point, the material will deform elastically and will return to its original shape when the applied stress is removed. Once the yield point is passed, some fraction of the deformation will be permanent and non-reversible.

4. Significance and Use

4.1 This guide is intended to assist the user in selecting strapping material(s) and application method(s) for evaluation when subjected to handling, transit, and storage tests. It describes general load, unit and package types, strapping properties, strapping performance, weight considerations, shear planes, component frictional characteristics, and geometry.

5. Safety Hazard Guidelines

5.1 Safety guidelines need to be followed to avoid personal injury or death. Examples of safety guidelines are presented below. Users should consider engaging an individual qualified by training to conduct a risk assessment on all strapping applications to determine best safety practices.

5.2 *Strap Cutting*—When straps are under tensional loading, the release of this tension will produce a hazard when the loose ends snap free after being intentionally or accidentally cut, frayed, or otherwise released. Contents under restraint or the strap itself, or both, may spring toward or fall upon the operator or a bystander when strap tension is suddenly released. *Cutting tensioned strap is hazardous*. Use caution and follow approved safety procedures. (See [Fig. 2](#).)

5.2.1 Strap Cutting Techniques:

(1) Wear safety gloves and eye protection when working with steel or nonmetallic strapping.

(2) Keep a safe distance away from the danger zone. (See the Gray Area in [Fig. 2](#).) When tensioned straps that secure a load, unit, or package are cut the contents could shift or fall. Bystanders need to be in an area where they will not be struck by flying or flailing strap ends when the strapping is being cut.

(3) Never stand under a strapped load, unit, or package. Never stand directly in front of a load, unit, or package secured by a strap being cut.

(4) Stand to one side of the strap being cut.

(5) Use one hand to hold the strap firmly against the load, unit, or package. Never place your hand on or near the seal while cutting the strap. (See [Fig. 2](#).)

5.2.2 Always wear proper Personal Protective Equipment (PPE) such as gloves, eye protection, steel toe safety shoes, etc., when working with steel or nonmetallic strapping.

5.3 Excessive tensioning may cause strap breakage. Always position yourself to one side of strap being tensioned. Never stand directly in-line of a strap being tensioned.

5.4 *Strapping Tools*—Read and understand all instructions before operating any tool.

5.4.1 Never operate the tool in such a manner that could result in a loss of balance or loss of control of the tool, the load, unit, or package secured by the strap.

5.4.2 Never extend the length of the handle on a manual tensioner, or exceed the manufacturer's recommended maximum air pressure on pneumatic tensioners to gain increased strap tension. To do so could result in sudden strap failure or breakage of the tensioner. This could result in serious or fatal injury to the operator.

5.5 *Seals and Joints*—An improperly formed strap joint can result in premature failure and an unstable load, unit, or package. (See [Section 12](#).)

5.6 *Strapping Alignment*—Apply strapping perpendicular to any edge (corner). A strap being applied and tensioned at an angle (edge loaded) may induce strap failure. Eventually the strap could shift to proper alignment position, resulting in a loose strap and product shift. (See [17.1](#).)

5.7 *Improper Use*—Use strapping only as intended by the supplier and consistent with all applicable regulations, standards, warnings, and instructions.

5.7.1 *Drilling, Punching, or Nailing*—Never drill holes in strapping. Never punch strapping with nails, staples, or other sharp objects. This may cause premature strap failure that could result in serious or fatal injury. Attempting to nail/staple through steel strapping may present a hazard, such as strap failure or ricocheting of a nail/staple. For nail-on applications, use Type 2 steel strapping that has pre-punched holes.

5.7.2 *Pulling or Dragging*—Never use strapping as a means of pulling or dragging any load, unit, or package.

5.7.3 *Lifting*—Never use strapping as a means of lifting unless using the Unit Strap Lifting Method (USLM) system. (See [5.9](#) to [5.9.6](#).)

5.8 *Reuse*—Never reuse steel or nonmetallic strapping, since the mechanical properties of strapping may be altered by tensioning, during handling/shipping, or after having been applied in the first instance.

5.9 *Unit Strap Lifting Method (USLM)*—Before considering a USLM application, consult your USLM system vendor and transportation or Port Regulatory Authorities for application rules and specifications. The following warnings are in addition to the previously listed safety hazards. (See [5.2](#) through [5.8](#).)

5.9.1 *Compliance and Training*—Compliance with all safety aspects of USLM application is critical to protect personnel. Always train all users before using the USLM or handling USLM loads.

5.9.2 *Specified Strapping, Tools, and Seals*—Always use correctly marked USLM steel strapping and seals. (See Specification [D3953](#).) Crimp type seals must be used and be applied with a crimp type sealer. The strapping must be applied so that the USLM markings are visible.

5.9.3 *Lifting Capacity*—Consult transport company or Port Authority Regulations, and your USLM system supplier to determine the lifting capacity of strapping. Never exceed the calculated lifting capacity.

5.9.4 *Damaged or Used Straps or Seals*—Never use damaged or used USLM strap or seals.



TABLE 1 Strapping Applications Commonly Used for Packaging, Unitization, and Load Securement

For guidance purposes only. The strapping types and sizes indicated for specific applications are typical. The table is not intended to recommend or specify.												
Specification D3953 for Strapping Flat Steel and Seals												
Industry	Product	Hand or Machine Applied			Hand Applied			Hand or Machine Applied			Type IV Polyester	
		Type I Steel Regular Duty	Type I Steel High Strength	Type I Steel Heavy Duty	Type IA Bonded, Woven, or Composite Polyester Cord	Type I Bonded Rayon Cord	Type II Polypropylene	Type III Nylon				
General	Appliances Carton Closure Flat Glass PVC Pipe	Moderate Tensile Strength Low Elongation High Retained Tension Well suited for rigid and moderate expanding units Not well suited for shrinking units.	High Tensile Strength Low Elongation High Retained Tension Well suited for rigid and moderate expanding units Not well suited for shrinking units.	High Tensile Strength Moderate Elongation High Retained Tension Well suited for rigid and moderate expanding units Not well suited for shrinking units.	Good Tensile Strength Moderate Elongation Good Retained Tension High Energy-to-Break Good Notch Sensitivity Well suited for shrinking, rigid, and expanding units.	Moderate Tensile Strength Moderate Elongation Good Notch Sensitivity Well suited for shrinking, rigid, and moderate expanding units.	Low Tensile Strength High Elongation Low Retained Tension Good Tension Recovery Well suited for shrinking and expanding units.	Moderate Tensile Strength Good Elongation Good Retained Tension Good Tension Recovery Well suited for shrinking, rigid, and expanding units.	Good Tensile Strength Moderate Elongation Good Retained Tension High Energy-to-Break Well suited for shrinking, rigid, and expanding units.			
		3/8 " & 1/2 "				3/16 " , 1/4 " & 3/8 "	7/16 "	7/16 "	5/8 "			
			5/8 " & 3/4 "		5/8 " & 3/4 "		1/4 " & 3/8 "			5/8 " & 3/4 "		
		3/4 "	5/8 " & 3/4 "		1/2 " , 5/8 " & 3/4 "		7/16 "		1/2 " , 5/8 " & 3/4 "			
Agriculture	Food Products in Wood Bins Hay Baling Cotton Tobacco Fibers (Manmade & Natural) PET Bottles			3/4 "					5/8 "			
							1/2 "		1/2 "			
				3/4 "						1/2 "		
				1/2 " , 5/8 " & 3/4 "			1/2 "			5/8 " & 3/4 "		
Beverage	Cans Glass Bottles								3/8 "			
										3/8 "		
										7/16 " & 1/2 "		
										7/16 "		
Corrugated	KD Boxes Corrugated Sheet Bundles	3/8 "								7/16 "		
		3/8 " , 5/8 " & 3/4 "								7/16 " & 1/2 "		
Graphic Arts	Signature Logs Magazines Newspapers Palletized Printed Loads									7/16 " & 1/2 "		
										5 mm, 3/16 " & 1/4 "		
										5 mm, 3/16 " & 1/4 "		
Masonry	Brick Block/Pavers Roof Tiles											
Forest Products	Lumber Hardwoods Hardboard Siding Pressure Treated Lumber Landscape Timbers	5/8 " & 3/4 "	1/2 " , 5/8 " & 3/4 "	5/8 " & 3/4 "	5/8 " , 3/4 " , 1" & 1 1/4 "					5/8 " & 3/4 "		
		3/4 "		3/4 "	5/8 " & 3/4 "					3/4 " & 1"		
		5/8 " & 3/4 "		5/8 " & 3/4 "	5/8 " & 3/4 "					5/8 "		
		5/8 " & 3/4 "	5/8 " & 3/4 "	5/8 " & 3/4 "	5/8 " & 3/4 "					5/8 "		
Panel Products	Flakeboard, MDF, OSB, Particleboard & Plywood											
Engineered Wood Products	I-Joists, LVL, PSL & LSL											